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CHEMICAL & ENGINEERING

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The electronics revolution.
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Chemical Companies Tighten Up Cash Management

C&EN survey shows that in 1982, cash stores rose as inventories, receivables, and short-term debt all decreased sharply

David Webber, C&EN New York

Most of the attention paid to the much-ballyhooed reduction of inventories in the chemical industry in 1982 has focused on its potential impact on capacity utilization this year. But the cutback, which paves the way for renewed production when demand picks up, has had a more im-

mediate impact on the balance sheet. There, the inventory trimming capped a two-year trend toward tighter management of day-to-day cash flow that has included sharp reductions in accounts receivable and short-term debt.

Industry customarily attempts to improve its liquidity (cash and relative cash coverage of liabilities) during recessions. To do so, it must plug the biggest short-term cash drains—inventories and receivables. If it can, it reduces its financing requirements, and short-term debt tends to decline. Total cash and marketable securities (short-term investments and the like) increase.

On average, chemical companies

achieved these goals last year. A C&EN survey of the annual reports of 20 U.S. companies with a large share of the industry's basic chemicals production shows a 6% rise in cash and marketables in 1982 after an equal rise the year before. This compares with a drop in 1980, the previous recession year (when companies had a more difficult time believing they were actually in a recession), and a 12% increase in 1975.

Still, the increase in cash was accompanied by only a slight improvement in liquidity. The broadest measure of a company's cash coverage of its liabilities, the current ratio (current assets divided by current liabilities) actually fell on average

Cash on hand and cash ratios rose last year

	1982 (recession)			1981			1975 (recession)			1974		
	Cash and marketables (\$ millions)	Current ratio	Cash ratio	Cash and marketables (\$ millions)	Current ratio	Cash ratio	Cash and marketables (\$ millions)	Current ratio	Cash ratio	Cash and marketables (\$ millions)	Current ratio	Cash ratio
Air Products ^a	\$ 64.3	1.2	0.14	\$ 95.9	1.3	0.22	\$ 37.2	1.3	0.19	\$ 45.8	1.4	0.28
Allied	176.0	1.3	0.15	181.0	1.5	0.13	86.0	2.2	0.27	72.8	2.0	0.22
American Cyanamid	319.8	2.0	0.42	215.2	1.9	0.26	154.1	2.4	0.46	179.4	2.4	0.53
Celanese	104.0	1.9	0.20	235.0	2.0	0.40	146.0	1.7	0.36	117.0	1.7	0.31
Diamond Shamrock	82.6	1.7	0.17	66.2	2.0	0.14	52.7	2.1	0.28	35.5	1.4	0.16
Dow Chemical	183.0	1.8	0.08	93.0	1.7	0.04	374.9	1.5	0.25	423.3	1.4	0.27
Ethyl	94.0	2.3	0.45	121.0	2.2	0.52	103.9	3.5	0.99	42.5	2.6	0.34
W. R. Grace	164.5	1.7	0.17	84.1	1.6	0.07	110.1	1.8	0.16	168.2	1.6	0.20
Hercules	34.2	2.2	0.10	27.5	2.6	0.08	28.4	2.0	0.12	22.2	2.0	0.08
Lubrizol	25.4	2.7	0.22	49.6	2.6	0.39	44.9	3.0	0.70	37.6	2.4	0.48
Monsanto	414.0	2.6	0.44	426.0	2.4	0.40	425.6	3.4	0.88	324.1	2.9	0.63
National Distillers	141.1	3.5	0.60	136.7	4.0	0.65	105.6	3.8	0.65	106.5	3.5	0.59
Olin	77.1	1.8	0.20	35.8	1.8	0.10	98.2	2.4	0.44	98.2	2.3	0.46
Pennwalt	14.7	1.9	0.08	9.1	2.2	0.05	21.9	3.1	0.22	2.2	2.0	0.01
PPG Industries	84.2	1.9	0.14	103.7	2.3	0.22	163.8	2.6	0.57	84.8	2.3	0.29
Reichhold Chemicals	15.2	2.7	0.22	6.4	2.5	0.07	5.6	2.2	0.11	22.8	2.3	0.45
Rohm & Haas	113.8	2.9	0.45	50.9	2.6	0.18	17.5	2.4	0.09	19.7	2.3	0.10
Stauffer Chemical	148.7	2.5	0.45	62.2	2.5	0.21	52.9	3.1	0.42	53.5	2.5	0.39
Union Carbide	154.0	2.0	0.09	253.0	2.2	0.15	585.1	2.5	0.55	426.1	2.2	0.38
Witco Chemical	49.0	2.2	0.32	68.2	1.8	0.31	14.5	2.4	0.26	14.6	1.9	0.19
TOTAL (average for ratios)	\$2459.6	2.1	0.26	\$2320.5	2.2	0.23	\$2628.9	2.5	0.40	\$2296.8	2.2	0.32
ANNUAL CHANGE	6%			6%			15%			-11%		

^a Fiscal year ends Sept. 30. Note: Current ratio is current assets divided by current liabilities. Cash ratio is cash and marketable securities divided by current liabilities.

Companies trimmed day-to-day financing needs in 1982

\$ Millions	% change			% change			% change			% change		
	Inventories	1982	1981	Receivables	1982	1981	Accounts payable	1982	1981	Short-term debt	1982	1981
Air Products ^a	\$ 112.9	13%	21%	\$ 303.3	3%	-2%	\$ 209.5	11%	4%	\$ 82.5	13%	115%
Allied	647.0	-23	40	728.0	-22	19	769.0	-21	45	38.0	-28	61
American Cyanamid	513.5	-4	8	681.4	-14	8	572.9 ^b	-6	-1	130.2	-4	73
Celanese	420.0	-5	13	454.0	-3	-9	367.0 ^b	-13	6	52.0	-18	29
Diamond Shamrock	348.6	-4	-7	325.2	-31	-7	301.0	1	11	19.1	-14	5
Dow Chemical	1746.0	-17	9	2,034.0	-12	7	1055.0	-21	12	276.0	-44	-33
Ethyl	161.5	10	2	206.7	-10	-6	70.5	-7	-5	18.4	-49	84
W. R. Grace	876.4	-5	12	620.2	-25	10	472.9	-11	7	176.0	-12	-12
Hercules	368.3	-10	21	380.5	-9	0	161.2	7	-2	57.9	-21	-51
Lubrizol	134.1	-6	-1	139.0	-2	-10	72.3	2	-10	0	0	0
Monsanto	824.0	-6	5	1,076.0	0	-20	379.0	-23	16	131.0	-25	-27
National Distillers	412.2	-5	2	243.3	-9	-9	107.6	3	-13	51.2	132	-4
Olin	265.3	-15	8	288.7	5	-6	136.2 ^b	-13	6	87.5	181	-56
Pennwalt	141.0	-8	-26	147.4	-10	-24	49.8	-17	-16	38.1	36	-62
PPG Industries	403.5	2	7	570.1	11	-2	483.4 ^b	39	-6	89.2	-17	85
Reichhold Chemicals	61.5	-25	11	99.0	-18	-10	41.4	-29	-16	9.9	-21	-22
Rohm & Haas	292.3	-23	18	230.6	-17	3	194.5 ^b	-13	86	60.1	8	70
Stauffer Chemical	279.1	-10	1	390.9	18	-9	99.4	-14	-18	113.6	73	-76
Union Carbide	1740.0	-9	1	1,420.0	-6	-5	415.0	-6	2	325.0	51	-32
Witco Chemical	96.9	-17	39	175.7	-12	4	140.9 ^b	-20	12	8.3	-37	99
TOTAL	\$9944.1	-9%	8%	\$10,514.0	-3%	-9%	\$6098.5	-10%	-19%	\$1767.0	-6%	-24%

^a Fiscal year ends Sept. 30. ^b Includes accrued liabilities.

among the 20 surveyed firms, from 2.2 in 1981 to 2.1 in 1982. In the 1974-75 period, by contrast, companies clearly approached cash management more rigorously, raising the current ratio from 2.2 to 2.5.

The current ratio does not give a complete picture of the industry's cash management, however, since companies were actively reducing inventories, which are a dubious asset in a liquidity measurement when demand is low. Using a different financial yardstick, the cash ratio (cash plus marketable securities divided by current liabilities), the chemical companies in the survey look better, managing a respectable improvement from 0.23 in 1981 to 0.26 last year. Nonetheless, the cash ratio achieved in this recession compares relatively unfavorably with that of the 1974-75 span, when it rose on average from 0.32 to 0.40.

On the whole, however, analysts say chemical producers weathered the recession in good fashion in financial terms. "I think they managed their cash very well," comments Robert Todd, chemical specialist for Citibank.

Indeed, 11 of the 20 surveyed firms increased their reserves of cash and

marketables last year. Most prominent were American Cyanamid, up 49%; Dow Chemical, up 97%; W. R. Grace, up 97%; Rohm & Haas, up 124%; and Stauffer Chemical, up 140%. A few companies had large decreases in cash on hand, notably Celanese, down 40%; and Union Carbide, down 39%. Five companies—American Cyanamid, Diamond Shamrock, National Distillers & Chemicals, Olin, and Pennwalt—increased their cash and marketables stores for the second year in a row.

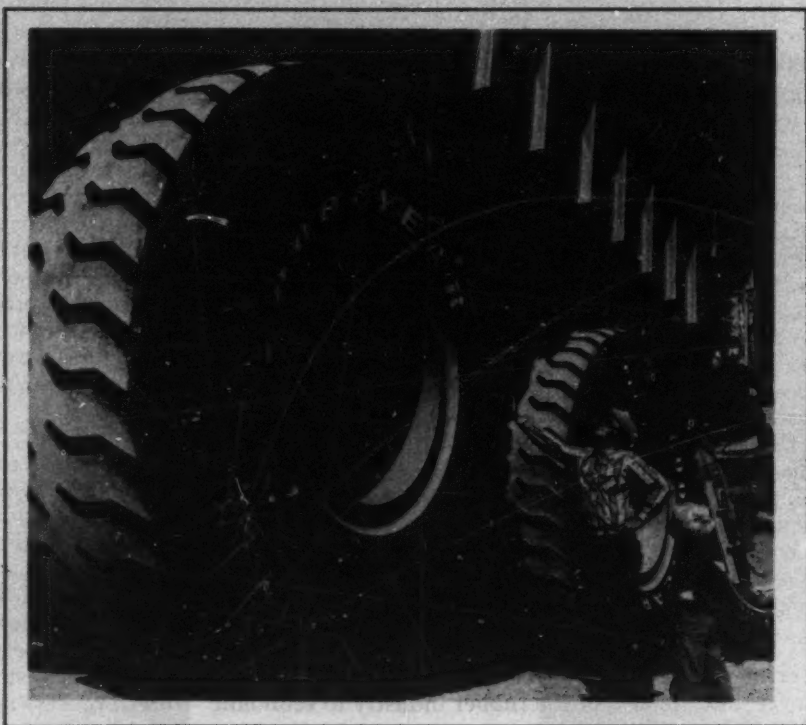
The overall increase was the result of greatly tightened financial controls. Inventories, which had grown 8% in 1981, declined 9% last year. Seventeen of the 20 surveyed producers cut their inventory levels, led by Reichhold Chemicals, down 25%; and Allied and Rohm & Haas, both down 23%. And although receivables were down only 3%, it was the second consecutive year of decline for eight individual companies and for the overall average.

As a result, the amount of short-term debt (both notes payable and that portion of long-term debt due this year) shrank for the second year in a row. Dow Chemical, still one of the most cash-poor chemical pro-

ducers (with a cash ratio of 0.08), cut its short-term debt load 44%. Eleven other firms registered mostly sizable decreases as well.

Dow's results, in fact, reveal one of the most concerted efforts at tightening up cash management in the industry. On both sides of the balance sheet, its improvements were far better than the average for the surveyed firms. But Dow, of course, was so low in terms of liquidity—a cash ratio of just 0.04 in 1981, for instance, and short-term debt of \$736 million in 1980—that it had the most to do. On average, the 20 companies' liquidity as they come out of the most recent recession is far below where it was in 1975, suggesting the industry may have decided that the average 40% coverage of current liabilities with cash it enjoyed then is not necessary. Indeed, only six firms now have a cash ratio above 0.35, compared to 10 firms in 1975.

And, as the recovery continues, the financial ratios built up at the end of 1982 will begin to erode. Inventories will rise again as companies prepare for demand, and receivables will increase as producers offer better terms to customers as a way to win market share. □



Rubber-Processing Chemicals Recover After 20-Year Low

Stephen C. Stinson
C&EN New York

The highly complex world of organic rubber-processing chemicals—involving dozens of companies in a more than \$400 million annual business—has begun a weak recovery in the U.S. this year after hitting a 20-year low in 1982. Production of these chemicals may rise 7% to 132,000 metric tons in 1983, if American auto makers, the prime customers, produce 6 million cars this year, or only 3% to 127,000 metric tons if they do not.

As U.S. economic recovery gets under way, rubber processors and chemical producers are adjusting to a new climate in marketing of organic rubber-processing chemicals. One main influence is a strengthening dollar, which is attracting a rising tide of imports. Another internal

matter shaking up the business is withdrawal of American Cyanamid from production of important workhorse accelerator types.

Over the longer term, renewed growth in rubber chemicals may be hampered by downsizing of tires for smaller cars, a trend that will not be complete until about 1990. Observers are divided about what effect this will have. Pessimists predict that downsizing will result in slower growth this decade for rubber chemicals than that of the gross national product. Those who are more optimistic point to the fact that tires will last longer in coming years, because people are not driving so much as they once did. According to this view, such tires will need increased levels of antioxidants and antiozonants to protect them from deterioration just while standing still over the increased number of years that

consumers will demand that they last.

Such other long-term trends in the rubber industry as possible elimination of spare tires as original automotive equipment and increased use of natural rubber may not have significant impacts on rubber-processing chemicals. If, as some in the industry think, auto makers succeed in getting buyers to accept cars with no spares in the next three to five years, this will result in a one-time-only impact on rubber chemicals. Tires will keep wearing out naturally, and rubber chemicals sales will resume growing through original equipment and replacement tire sales.

Use of natural rubber in the U.S. got a boost in the 1970s both because of the rise in feedstock prices for synthetic rubber and of the continuing conversion of tires to radial rather than bias-ply construction.

Rubber-processing chemicals: a definition

The organic rubber-processing chemicals described in this report are the 200-odd organic substances used by rubber compounders in making vulcanized rubber. With the exception of such products as crepe rubber shoe soles and adhesives, raw rubber has no other commercial use. It has to be extensively compounded first with specialized chemicals.

This report covers accelerators to speed the cross-linking reaction with sulfur, activators to potentiate the accelerators (sometimes called secondary accelerators), retarders to delay vulcanization, peptizers for viscosity reduction, antioxidants and antiozonants to protect rubber in processing and in use afterward, and sulfur donors to enhance quality of cross-links. Rubber

compounders use an average of 4.5 lb of these chemicals per 100 lb of raw rubber.

Organic chemicals not treated in this report include mercaptans that regulate polymerization of monomer to raw rubber, peroxides that initiate such polymerization, fatty acids added as activators, and the various oils used as extenders, softeners, and physical plasticizers.

Among inorganic substances excluded in this report are elemental sulfur as vulcanizing agent, zinc oxide and other oxide activators, carbon black reinforcements (an important, large volume constituent of finished tires), and other reinforcements and fillers such as alkaline earth carbonates and silicates, silica, and clays.

Because natural rubber latex contains antioxidant substances and fatty acids, processing requires no stabilizers or fatty acid activators. Such subtle differences in natural versus synthetic rubber processing will be difficult to detect, however, amidst

the overall boom-and-bust responses of the rubber industry to economic cycles.

Some two dozen domestic producers and a few major U.S. suppliers that import their chemicals all will vie for the approximately \$420 million worth of organic rubber-processing chemicals U.S. industry will use this year. If all these sales were made by one firm as its sole business, that firm would rank number 70 on C&EN's roster of top chemical producers. If the 200 or so such chemicals all were expressed as one chemical, its volume would be only one quarter of that needed to make it number 50 on C&EN's list of the Top 50 Chemicals.

Rubber chemical sellers are secretive about their shares of U.S. merchant sales, but observers agree that in the U.S., Monsanto is first, Uniroyal second, and R. T. Vanderbilt third. In the rest of the world, where the market is four times the size of that in the U.S., Monsanto is again the leader, with Bayer and Uniroyal tied for second place. The picture is complicated by the fact that three major rubber companies—B. F. Goodrich, Goodyear, and Uniroyal—produce captively for themselves as well as sell in the merchant market.

In terms of production, Monsanto may have a 35% share, 1983 sales of 45,000 metric tons worth \$160 mil-

lion. Goodyear's share may be 30%, or 40,000 metric tons valued at \$140 million. The company uses almost all of this internally, however. Uniroyal could produce about 15% of U.S. rubber chemicals, which would translate to 20,000 metric tons or \$70 million. Uniroyal is very aggressive in the merchant market, and may use only one third of its output in-house for rubber production. Goodrich could come in for as little as 5%, 7,000 metric tons worth \$25 million. This firm may use half of this volume captively.

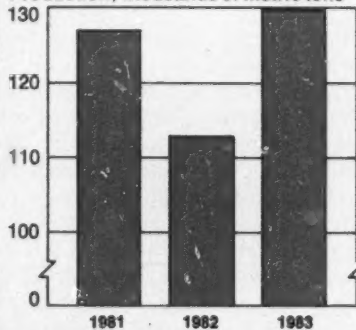
Exports of rubber-processing chemicals may come to 22,000 metric tons in 1983, worth almost \$80 million. In addition, some U.S. companies serve other areas of the world by maintaining production plants abroad. Predicasts of Cleveland, Ohio, a business information and research firm, estimates that growth in rubber consumption, and therefore of processing chemicals, will be greater in the less industrialized than in more industrialized countries. For example, a Predicasts study predicts worldwide increases of 4% per year, compared with only 1.3% annual growth in North America.

With imports to the U.S., the picture is less clear. Some observers say that the U.S. will import only 5,000 metric tons of rubber-processing chemicals in 1983, with a value of \$18 million. To others, the amount seems much higher—perhaps 15,000 metric tons and \$50 million. There is general agreement that declines in their own markets coupled with the rising value of the dollar have encouraged many foreign companies to move their products more aggressively in the U.S.

U.S. companies are responding to this new climate of relatively high growth potential in overseas markets, low expected growth in the U.S., intensifying competition everywhere, and the advance of imports into the U.S. Strategies include research on new chemicals, re-emphasis on technical service, production of nondusting grades of chemicals, and investment in foreign production. Perhaps the most drastic move was by American Cyanamid, which stopped making benzothiazole and sulfenamide accelerators in 1982.

Rubber-processing chemicals at a glance

Production, thousands of metric tons



Major classes: Accelerators, activators, and vulcanizing agents 32%; antioxidants and antiozonants 53%

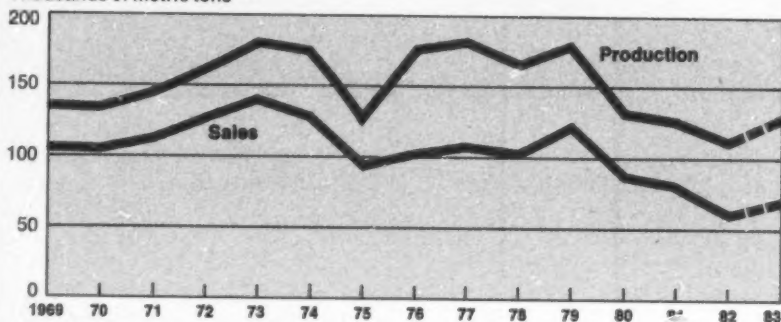
Foreign trade: Exports, 17% of U.S. production. Imports, 3% of U.S. consumption and growing rapidly

Prices: Average \$1.60 per lb

Commercial value: \$460 million for U.S. production in 1983

Rubber chemicals sales have slumped since 1979...

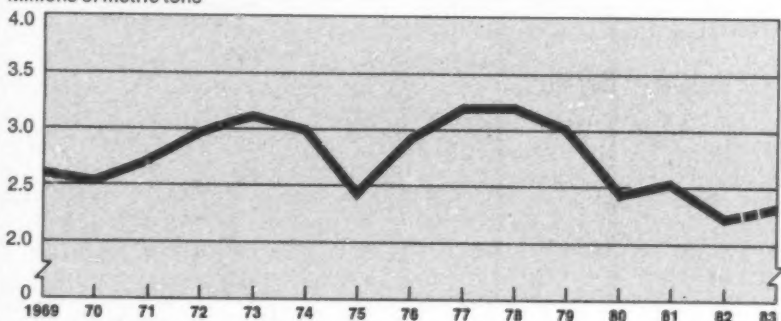
Thousands of metric tons



Sources: International Trade Commission, C&EN estimates

...and rubber consumption has been down since 1977

Millions of metric tons



Note: Rubber consumption includes natural rubber. Sources: Rubber Manufacturers Association, C&EN estimates

As American Cyanamid marketing manager William Bush explains, the withdrawal from these compounds came from a need to cease production at the company's Bound Brook, N.J., plant. "So many businesses had gone out of production at Bound Brook that fixed costs were being spread over a diminishing base," Bush says. "We also faced a large investment to renovate the plant."

The firm still is committed to serving the rubber industry with specialty chemicals. For example, the company has started U.S. production of an accelerator for neoprene rubber, 3-methyl-2-thiazolidinethione. This compound is of interest because of its potential to replace ethyl-enethiourea, which has been found carcinogenic in rats and mice. Another recent product from Cyanamid is a peptizer based on dithiobis(benzanilide) and an activator.

"We will compete by reducing our product line to specialties where we have positions in technology, man-

ufacturing costs, and raw materials that are as good as anyone else's," Bush says. "We will research new products in those areas, especially adhesion promoters, and limit our sales efforts to those areas."

Adhesion promoters enhance adherence of rubber to tire cord and so become increasingly important as radial tires continue replacing bias-ply types. This type of chemical system was one bright spot at Cyanamid and other rubber chemical firms in the overall gloom of 1982. According to the Rubber Manufacturers Association, which has broken out such figures only since 1981, sales of replacement radial tires rose almost 13% from 1981 to 1982, and the number of customers choosing radials as replacement tires grew from 61% to 66%. This more than overcame a drop of 5% in radials as original equipment as new car sales declined. As original equipment, the number of radial tires supplied with new cars remained about 84%.

Some companies have reacted to Cyanamid's withdrawal by starting production of accelerators such as *N, N*-diisopropylbenzothiazolesulfenamide, for which Cyanamid was the only U.S. producer. But one other rubber-processing chemicals company, Pennwalt, was caught short by Cyanamid's move. Pennwalt had an agreement with the New Jersey firm in which Cyanamid packaged accelerators under the Pennwalt label at Bound Brook. However, Pennwalt has managed to take Cyanamid's withdrawal in stride, according to John R. Smith, who is marketing manager for Pennwalt's rubber accelerator products department, and even fit the new situation into the overall reorganization of its rubber chemicals effort.

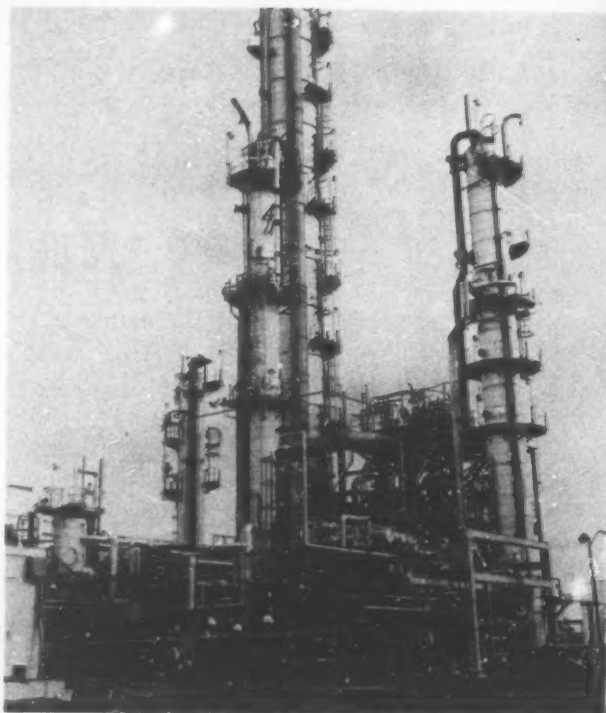
Before 1982, Pennwalt had sold accelerators to the rubber industry through its organic chemical division, as well as peroxide initiators of its Lucidol division in Buffalo, N.Y. Rubber processors use peroxides as vulcanizing agents when needed for maximum heat stability and minimum compression set. Realizing the need to concentrate its rubber chemicals marketing effort in the new climate of the 1980s, Pennwalt's management hired Smith in 1982 to organize the accelerator department in a new office in Hudson, Ohio, near Akron. The company reassigned sales of peroxides for the rubber industry to Lucidol.

The chemicals that Smith sells for Pennwalt in the U.S. will come from Italy. The company has long had a plant in Ticino, Italy, as a joint venture with Industria Chimica del Ticino to make dithiuram disulfides and dithiocarbamates. In mid-1982, the joint venture opened a \$15 million, 15,000 ton-per-year plant and research laboratory at Termoli to produce benzothiazoles. The two plants will produce for Pennwalt's needs in the U.S. and the rest of the world. The laboratory will work on new products Pennwalt must have to remain competitive this decade. For now, Smith is working to stock warehouses here with products from Termoli. In the future, he will bring on production of nondusting grades of chemicals. Perhaps his greatest competitive asset, Smith says, is the newness of the company's plants and

1979 was peak year for production of rubber processing chemicals in the U.S.

Thousands of metric tons	1981 ^a	1979	% change
Accelerators, activators & vulcanizers	43.2	60.1	-29%
Aldehyde-amine adducts	0.3	0.4	-25
Thiazoles	33.9	49.0	-31
2,2'-Dithiobis(benzothiazole)	5.5	7.5	-27
2-Mercaptobenzothiazole, zinc salt	0.7	0.9	-23
Dithiocarbamates	4.5	4.9	-8
Dimethyldithiocarbamate, zinc salt	0.8	1.7	-50
Thiurams, xanthates & sulfides	1.1	1.6	-27
Others ^b	3.3	4.8	-32
Antioxidants, antiozonants & stabilizers	67.7	85.9	-21
Amino compounds ^c	41.2	53.7	-23
Phenylenediamines	28.1	28.7	-2
Phenolics & phosphites	26.5	32.8	-18
Polyphenolics	4.2	6.1	-30
Alkylphenols	2.6	3.2	-13
Styrenated phenols	0.5	0.4	+20
Other phenolics & phosphites	19.0	22.5	-16
Others ^d	14.6	32.4	-55
TOTAL^e	126.8	179.0	-29%

^a Last year for which data are available. ^b Includes guanidines. ^c Includes acetone- and aldehyde-amine adducts. ^d Includes blowing agents, peptizers, lubricants, and polymerization regulators. ^e Figures do not add to total because of rounding. Source: U.S. International Trade Commission



Precursor for many rubber chemicals is aniline, produced here in USS Chemicals plant at Haverhill, Ohio

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processes, which will allow Pennwalt to compete successfully.

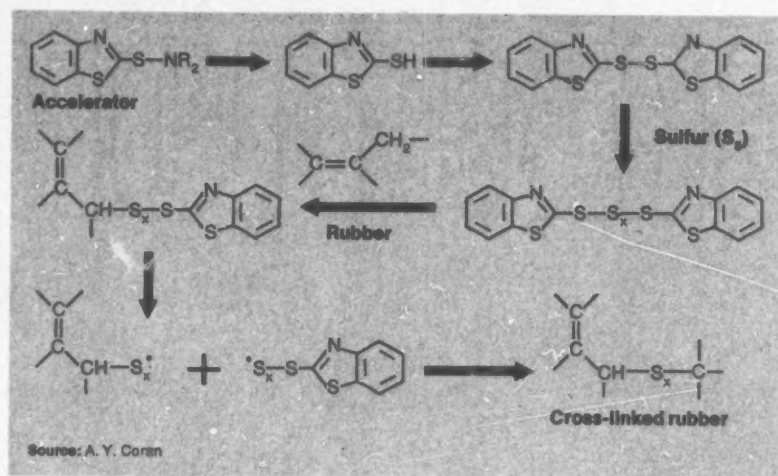
The competitive stance that everyone in the rubber industry watches is that of Monsanto, the leading supplier of rubber-processing chemicals to the industry. Says Roger Spiller, who is business director for that business, "Rubber chemicals have been a good business for Monsanto. We are dedicated to maintaining our position."

"We have some interesting research projects, looking for chemicals that will benefit us and the industry. We will continue our heavy emphasis on technical service, which we feel the industry values."

"Consistent with the present tough economic times in the rubber industry, we continue to take a hard look at the investments needed to maintain that position. Monsanto has an emphasis on asset management. We're taking a hard look at the inventories we keep and where we keep them. We will maintain our historic level of service with the minimum possible inventory."

The second leading merchant seller in the U.S., Uniroyal Chemical, presents a picture of a major rubber products company that consumes

Accelerators catalyze formation of sulfide cross-links



part of its production of processing chemicals captively. Robert Mazaika, who rose through the ranks to become general manager of the rubber chemicals business in 1982, says the company will continue its record of technological innovation and ex-

pansion into overseas production. Mazaika points out that Uniroyal pioneered in *N*-alkyl-*N'*-aryl-*p*-phenylenediamine antiozonants, as well as blowing agents based on hydrazine.

Uniroyal recently expanded ca-

capacity at its two joint-venture companies, Ameyal in Mexico City and Premier Chemical Co., Taipei, Taiwan. In addition to its U.S. plants in Geismar, La., and Naugatuck, Conn., the company owns Uniroyal do Brasil, with plants at Rio Claro and Maua; Uniroyal Chimica, Latina, Italy; and Uniroyal Ltd. (Canada), which produces at Elmira, Ont., and Clover Bar, Alta.

Explaining his investment strategy abroad, Mazaika says, "We base decisions on patterns of customs duties and stages of development in various countries. Developing countries eventually reach a stage of rubber consumption that demands local production of rubber chemicals. Also, most major rubber companies are located around the world, and it's good for them to be able to choose the same supplier everywhere."

"We service our customers at lowest cost in terms of customs duties. For example, we service customers in the U.K. from our plants in Canada."

Among new products introduced



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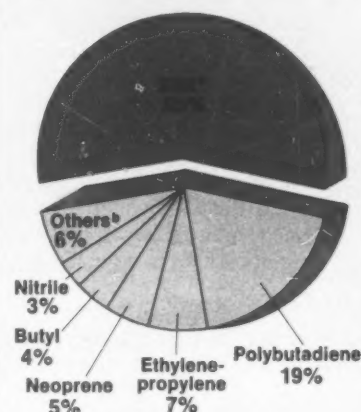


White crumbs of synthetic rubber move along drying tower at Goodyear's plant at Beaumont, Tex.

by Uniroyal are an activated azodicarbonamide blowing agent intended to replace dinitrosopentamethylenetetramine, a *p*-phenylenediamine antiozonant, and a hindered-phenolic antioxidant that is also a metal deactivator. Such metals as copper, which can alternate between different oxidation states, catalyze oxidation of rubber. Metal deactivators chelate these ions and inhibit this catalytic effect. Uniroyal's new compound with a combined effect is *N,N'*-oxamidodi-2-ethyl bis[3-(3,5-di-*tert*-butyl-4-hydroxyphenyl)-propionate].

Two other rubber companies that produce rubber-processing chemicals for captive use and also sell in the merchant market are B. F. Goodrich and Goodyear Tire & Rubber. Both firms produce chemicals for the accelerator and the antioxidant/antiozonant systems of rubber compounding. In agreements that are 60 years old, Goodrich distributes its antioxidants and Goodyear its accel-

SBR leads among synthetic rubbers in volume



Total 1982 consumption
= 1,624,800 metric tons

^a Styrene-butadiene rubber. ^b Includes polyisoprene and silicones.
Source: Rubber Manufacturers Association

Glossary of rubber terms

Accelerator. Speeds cross-linking of rubber by sulfur. Example: 2,2'-di-thiobis(benzothiazole).

Activator. Renders accelerators more potent. Example: 1,3-diphenylguanidine.

Antioxidant. Protects cured rubber parts against oxidative degradation in service. Antioxidants that protect synthetic rubbers before and during processing are **stabilizers**. Examples: *N*-isopropyl-*N'*-phenyl-*p*-phenylenediamine, which also is an antiozonant, and octylated diphenylamine, which is not.

Antiozonant. Additive that protects rubber parts against ozone. Examples: waxes, which migrate continuously to the surface to form a barrier, and *N,N'*-bis(1,4-dimethylpentyl)-*p*-phenylenediamine, which reacts with ozone and/or products formed by the reaction of rubber with ozone.

Bonding agent. Increases rubber adherence to fabric or fiber. Example: resorcinol plus hexamethylenetetramine.

Cure. Cross-linking of rubber polymer chains to impart elastomeric properties,

as by sulfur, peroxides, or quinone oximes. Also called vulcanization.

Cure time. Time needed for rubber compounds to reach maximum viscosity or modulus at a given temperature; the sum of the scorch time and cross-linking time.

Hard rubber. Rubber cured with 15 to 40% of added sulfur.

Latex. Water emulsion of rubber polymer, used as is for coating or dewatered for making solid parts.

Lubricant. Additive that eases flowing in molds or extrusion.

Mastication. Preliminary physical and chemical breakdown, usually of natural rubber, in a mill or mixer to reduce viscosity for further compounding.

Peptizer. Compound that promotes chemical breakdown of rubber during mastication. Also called **plasticizer**. Example: pentachlorothiophenol.

Phr. Parts-per-hundred-rubber; the number of parts by weight of compound added to 100 parts of rubber.

Retarder. Additive that lengthens time before curing. Example: phthalic anhydride. Sulfenamide retarders like *N*-

cyclohexylthiophthalimide have acquired the separate name of **prevulcanization inhibitors**.

Reversion. Decrease in viscosity or modulus of rubber from excessive working.

Scorch. Premature curing.

Scorch time. Safety margin of time that rubber compound can be worked at a given temperature before curing begins.

Soft rubber. Rubber cured with 0.5 to 8% of sulfur.

Stabilizer. Antioxidant that protects synthetic rubber from oxygen, heat, and light degradation, from newly polymerized latex through fabrication. Example: tris(nonylphenyl) phosphite.

Sulfur donor. Organic polysulfide that replaces some sulfur in rubber compounds and promotes curing mostly by monosulfide cross-links in a process called **efficient vulcanization**. Example: tetramethylthiuram disulfide.

Vulcanizing agent. Substance that cures rubber by forming cross-links between polymer chains. Examples: sulfur, sulfur donors, peroxides, quinone derivatives, and phenolic resins.

erator-related products through R. T. Vanderbilt Co., Norwalk, Conn. In turn, Goodrich sells its accelerators and Goodyear its antioxidants through their own sales forces.

John E. Stroope, general manager for Goodrich's rubber chemicals, is one of those who have felt the ripple of American Cyanamid's shutdown of accelerator production. Of his own firm's plans, he says, "We do plan to compete. We have no plans to withdraw. People asked us that after American Cyanamid's move."

Goodyear does not produce rubber chemicals outside the U.S., but sells products of its U.S. plants in Akron and in Henry, Ill., overseas. "We want a role in the international market," says Stroope. "I think rubber chemical exports have held up throughout the industry generally, because companies view the international market as important and are willing to accept problems of recession here and of currencies in other countries. You can see from other companies' production overseas how importantly they view it."

Meanwhile, Goodyear is responding to the new rubber chemicals selling climate by involving its research people more in marketing. Joel Muse Jr., for example, who is Goodyear's manager of organic chemicals research and development, will work more closely with the sales side in the future. Development of new products and modernization of its plants also will figure greatly in improving the company's competitive stance.

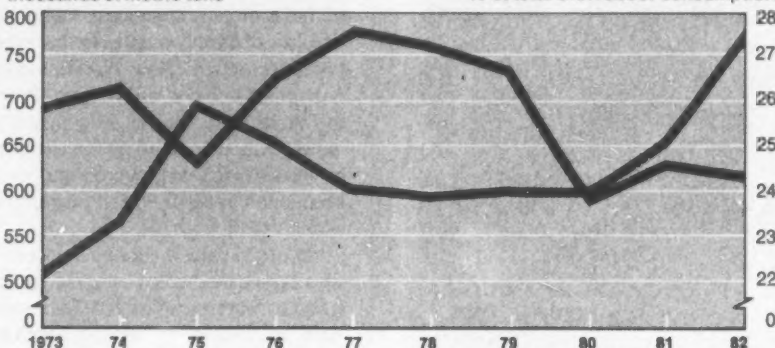
"We will be more aggressive in the marketplace," says Muse. "Our applications R&D people are going to be out there more in the near future. We're reorganizing our effort. In the past, we had two applications groups, one for rubber chemicals and another for rubber. We're going to combine these into one applications group. Part of that group will be out in the field a great deal of the time, making calls with the salesmen. The other part will be back doing the needed work to get our products to work and to introduce new products."

One recent product from Goodyear is an antioxidant that Muse describes as a *para*-oriented styrenated diphenylamine. Though he will continue research on new chemical types,

Radial tire growth brings resurgence for natural rubber

U.S. natural rubber consumption, thousands of metric tons

% of total U.S. rubber consumption



Source: Rubber Manufacturers Association

Muse says that the next advances may come through new formulations. "We're looking for cheaper antioxidants," Muse says. "There is a lot of interest in antioxidants that are synergistic with others, so you use less compound. We're also interested in polymer-bound antioxidants, and we have a promising prospect in that area."

Goodyear recently announced that it is spending \$15 million to modernize plants in Bayport, Beaumont, and Houston. Some of that will go toward improving production and processes for rubber chemicals. In the future, the company will appropriate more money to extend the modernization of its other domestic plants.

In addition to distributing rubber-processing chemicals produced by Goodrich, Goodyear, and many other companies, domestic and foreign, Vanderbilt produces for itself at Bethel, Conn., and Murray, Ky. Sales manager Donald Gorman says the company will rely on new products and a recently formed joint venture in Mexico to compete in the 1980s. But most important will be its current high quality of service. Gorman points to the 16 warehouses the company has in the U.S. and Canada, more than any other firm. He says that Vanderbilt's sales force are industry veterans, having come from such posts as technical director at other companies. Thus they can double as technical service and sales representatives. Vanderbilt also publishes extensively on rubber compounding. Its handbook, a



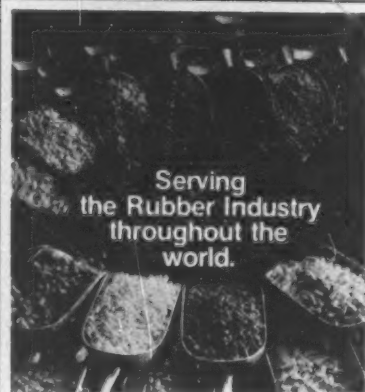
Tapper cuts rubber tree in Sumatra for creamy latex used in radial tires

1000-page tome with formulating information about dry rubber goods, was last put out in 1978. The next edition will appear in 1988. Vanderbilt is also at work on a similar book on latex rubber compounding for 1984. The most recent edition came out in 1954.

Vanderbilt's joint venture with Artivi of Mexico City is only six months old, so the company has not yet benefited from production there. Gorman expects the arrangement to



Innovations in finished rubber include this spraying technique by Goodyear, used here on fuel cells



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Origin of rubber goes back to the Aztecs

Before reaching its sophisticated current level of compounding using a host of complex organic chemicals, rubber had a history of development going back four centuries. A true New World product, natural rubber first showed up among the Aztecs in Mexico. The synthetic variety was pioneered by the Germans in World War I and levered into mass production in the U.S. and Germany in World War II.

1521: Spanish conquistadors in Mexico see the Aztecs using a gum from trees to waterproof utensils and make balls for games. Europeans adopt the South American Indian word "caoutchouc" for the gum, derived from "caa" (tears) and "ochu" (wood).

1770: Joseph Priestley writes to a friend that a piece of the gum makes a good "rubber" to erase pencil marks, but he is probably not the first person to use the word.

1819: Manufacture of rubber articles begins in England; products eventually include waterproof shoes and the raincoat invented by Charles Macintosh. But rubber goods are still inferior, becoming sticky in summer and brittle in winter.

1839: Charles Goodyear accidentally discovers that a compound of rubber, sulfur, and lead carbonate cures to a hard, resilient, infusible solid on heating. Thomas Hancock discovers the process independently and coins the term "vulcanization." Goodyear gets a patent, U.S. 3633, June 15, 1844.

1876: British entrepreneurs bring 70,000 seeds of the rubber tree, *Hevea brasiliensis*, to England from Brazil, which previously has had a monopoly on world rubber production. The British send 3000 seedlings, grown in Kew Gardens, London, to start plantations in Ceylon and Malaya. By 1900, plantings reach 4000 acres in these two countries.

1906: George Oensager at Diamond Rubber Co., Akron, discovers that ani-

line accelerates vulcanization. This compound becomes the first in a long line of organic accelerators to be commercialized in coming decades.

1910: Recent invention of the automobile stimulates production of 94,000 tons per year of natural rubber as prices skyrocket to \$3.12 per lb. Chemistry professor Carl Dietrich Harries of the University of Kiel, Germany, discovers that sodium catalyzes polymerization of 2,3-dimethylbutadiene to a synthetic "methyl rubber."

1918: By the end of World War I, Germany has produced a total of 2350 tons of methyl rubber.

1927: German chemists begin development of Buna S (butadien-natrium-styren) rubber, spearheaded by work of chemistry professor Karl Ziegler at the University of Heidelberg. The first German patents begin appearing on rubbers made by reactions of di- and trichloroalkanes with alkali polysulfides.

1931: Du Pont announces neoprene, a synthetic rubber made from 2-chloro-1,3-butadiene (chloroprene), whose commercial synthesis was developed by Wallace H. Carothers.

1942: Cut off from imports of natural rubber during World War II, the U.S. government orders planting of 75,000 acres of the guayule shrub. After the war, efforts on guayule rubber will be abandoned. U.S. industry gears up to produce various synthetic rubbers, which will amount to 700,000 tons per year in 1945.

1955: Studies of tire cracking in the smog-laden atmosphere of Los Angeles implicate ozone as the cause, leading to use of antiozonants in rubber formulations.

1983: World rubber production is 12 million tons per year, of which only 30% is natural rubber. The U.S. consumes 2.5 million tons this year, 25% of it natural.

assist marketing efforts in Latin America. On the new products front, Vanderbilt recently introduced the zinc salt of 2-mercaptotoluimidazole, an antioxidant that is synergistic with others.

Among U.S. rubber-processing chemical producers, Mobay Chemical Corp., Pittsburgh, has not yet

reached the commanding position in this country that its parent, Bayer of Leverkusen, West Germany, enjoys worldwide. Concerning Mobay's plans to compete here in the 1980s, product manager Al Rizzer says, "Our advantage is that we have the broadest product line of anyone. We can put together the broadest pack-

ACS Rubber Division is largely independent organization

The American Chemical Society's Rubber Division is a dynamic organization with a long tradition of moving in an independent sphere. Current membership tops 4300, of whom only half are members of ACS. This number includes 68 students and 325 emeriti. Almost a mirror image of ACS, the division has 23 local sections, called rubber groups, of which the largest are in Akron, Los Angeles, Chicago, Detroit, and locations making up the Southern Rubber Group.

The Rubber Division has its own system of courses and books; and a monthly journal, *Rubber Chemistry & Technology*, is sent free to members. The journal also has 1100 paid subscribers at \$60 per year among companies and libraries. The division publishes monographs and meeting symposia independently as well as texts for its courses.

The elementary correspondence

course often is taken by sales people and technical secretaries, and is an introduction to rubber science and terminology. More than 12,000 persons have taken it to date. The division soon will offer an intermediate course between the elementary course and the advanced course, which has become too advanced.

There are two national meetings in spring and fall. The fall 1982 meeting in Cleveland drew an attendance of 2000 and occupied four hotels. The division selected Toronto, Ont., for its spring 1983 meeting, May 9-12. The fall meeting will be in Houston, Oct. 25-27.

Marjorie E. Bauer opened the headquarters office 20 years ago at the University of Akron, Ohio 44325. It is she who collects annual dues of \$15 for members and \$3.00 for students. A full-time information scientist in the office performs computer searches of the

literature and has access to libraries at the university and at the major rubber companies in the area. The only holdings of the office's own library are a collection of papers from past meetings and a complete run of *Rubber Chemistry & Technology*.

The division set out on a road separate from ACS in the 1920s owing to finances and a desire of members to meet more intimately among themselves. When meeting attendance had grown quite large, the leaders of that day realized they could hold their own meetings and operate independently on finances. Also, because informal meetings in hallways and hospitality suites are at least as important as the technical sessions, members wanted to be housed together in the same bloc of hotels.

The division retains a connection to ACS, participating in the Macromolecular Secretariat and sometimes appearing as cosponsor of other divisions' symposia at ACS national meetings.

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age for a customer. Besides that, we have our technical service laboratory in Pittsburgh and a network of distribution centers throughout the eastern U.S. So our strategy will be service and a broad product line."

Among newcomers to Mobay's product line in the U.S. are the 3-methyl-2-thiazolidinethione accelerator for neoprene, intended to replace ethylenethiourea, and *N,N*-diisopropyl-2-benzothiazolesulfenamide, which Cyanamid discontinued. These products, like most of Mobay's line, will be imports.

As far as production in the U.S. is concerned, Mobay has begun to make an antiozonant, *N*-(1,3-dimethylbutyl)-*N'*-phenyl-*p*-phenylenediamine, and to formulate a plasticizer based on pentachlorothiophenol at its Bushy Park, S.C., plant. In addition, the company makes a bonding agent in New Martinsville, W.Va.

"This domestic production forms a base for our imported products," Rizzer says. Concerning the possibility of producing other rubber chemicals in the U.S. in the future, he says, "We're always thinking domestic. It's always in the back of our minds." □